Chemistry 6A Fall 2007

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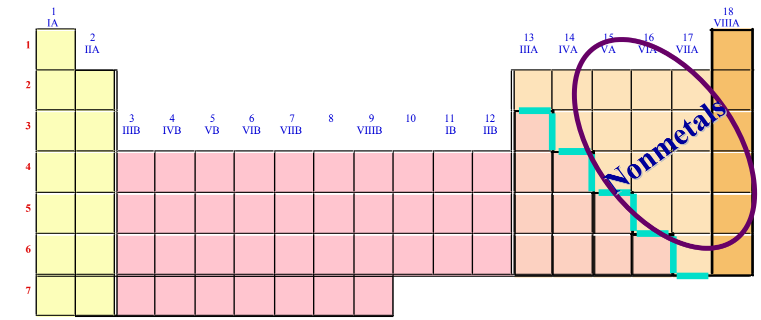
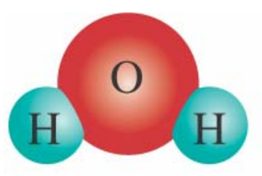
Molecular Compounds:

Nonmetals and Nonmetals



A water molecule consists of two hydrogen atoms and one oxygen atom.



If it is decomposed, the water molecule will be destroyed liberating hydrogen and oxygen.

A ***diatomic molecule*** contains exactly two atoms of the same or different elements.

Some elements exist in nature as diatomic molecules.

Table 3.6 Elements That Exist as Diatomic Molecules

Element	Symbol	Molecular formula	Normal state
Hydrogen	H	H_2	Colorless gas
Nitrogen	N	N_2	Colorless gas
Oxygen	O	O_2	Colorless gas
Fluorine	F	F_2	Pale yellow gas
Chlorine	Cl	Cl_2	Yellow-green gas
Bromine	Br	Br_2	Reddish-brown liquid
Iodine	I	I_2	Bluish-black solid

Molecular compounds: non-metal with a non-metal

When non-metals combine, they form molecules. They may do so in multiple forms:

CO CO_2

Because of this we need to specify the number of each atom by way of a prefix.

1 = mono 2 = di 3 = tri 4 = tetra

5 = penta 6 = hexa 7 = hepta

Examples:

Formula	Name:
BCl_3	boron ***tri***chlor***ide***
SO_3	sulfur ***tri***oxide
NO	nitrogen ***mono***xide

we don't write: nitrogen ***mono***oxide or ***mono***nitrogen ***mono***xide

N_2O_4	***di***nitrogen ***tetra***oxide

Avogadro's Number and the Mole

The number of particles that is equal to one mole is an empirical value (i.e. it is found experimentally).

$N_A = 6.022142 \times 10^{23}$ particles or individuals units.

Molar Masses

Since we can equate mass (*how much matter*) with moles (*how many particles*) we now have a conversion factor that relates the two.

The Molar Mass of a substance is the amount of matter that contains one-mole or 6.022×10^{23} particles.

Recall that the ***molar mass*** of each element is simply the atomic mass expressed in units of grams per mole.

		$\frac{g}{mole}$
Hydrogen atom: H	1.0079 amu	$\frac{1.0079\text{g H}}{1\text{ mole H}}$
Copper atom: Cu	63.55 amu	$\frac{63.55\text{g Cu}}{1\text{ mole Cu}}$

Molar Masses (*Molecular Weights*) of Compounds:

The molar mass of a ***molecular compound*** is the sum of the molar masses of its atoms.

Example:

The molar mass of CO_2 is:

1 x (12.01 g/mol) + 2 x (16.00 g/mol)

= 44.01 g/mol

$Ba_3(PO_4)_2$

3 Barium atoms

2 phosphorous atoms

$2 \times 4 = 8$ oxygen atoms

Barium Phosphate: $Ba_3(PO_4)_2$

Ba: $137.33 \frac{g}{mol}$

P: $30.97 \frac{g}{mol}$

O: $16.00 \frac{g}{mol}$

$$3 \times 137.33 \frac{g}{mol}$$

$$+2 \times 30.97 \frac{g}{mol}$$

$$+2 \times 4 \times 16.00 \frac{g}{mol}$$

$$601.93 \frac{g}{mol}$$

How many moles of benzene, C_6H_6, are present in 390.0 grams of benzene?

The molar mass of C_6H_6 is 78.12 g.

Conversion sequence: grams $C_6H_6 \rightarrow$ moles C_6H_6

Use the conversion factor: $\dfrac{78.12 \text{ grams } C_6H_6}{1 \text{ mole } C_6H_6}$

$$(390.0 \text{ g } C_6H_6) \times \left(\frac{1 \text{ mole } C_6H_6}{78.12 \text{ g } C_6H_6}\right) = 5.000 \text{ moles } C_6H_6$$

A sample of ammonium dichromate contains 1.81×10^{24} nitrogen atoms.

What is the mass of this ammonium dichromate sample?

ammonium dichromate

NH_4^+ $Cr_2O_7^{2-}$

$(NH_4)_2Cr_2O_7$

From the formula: $(NH_4)_2Cr_2O_7$ For every one formula there are two nitrogen atoms.

and… there are 2 moles of N-atoms for every one mole of ammonium dichromate

$$\frac{1\ (NH_4)_2Cr_2O_7}{2\ \text{N-atom}} \longrightarrow \frac{1\ \text{mol}\ (NH_4)_2Cr_2O_7}{2\ \text{mol N-atom}}$$

The plan:

N – atoms → moles of N – atoms → moles of $(NH_4)_2Cr_2O_7$ → g $(NH_4)_2Cr_2O_7$

A sample of ammonium dichromate contains 1.81×10^{24} nitrogen atoms.

What is the mass of this ammonium dichromate sample?

$$1.81 \times 10^{24}\ \text{N-atoms} \times \frac{1\ \text{mol N-atoms}}{6.022 \times 10^{23}\ \text{N-atoms}} \times \frac{1\ \text{mole}\ (NH_4)_2Cr_2O_7}{2\ \text{mol N-atoms}} \times \frac{252.08\text{g}\ (NH_4)_2Cr_2O_7}{1\ \text{mole}\ (NH_4)_2Cr_2O_7} =$$

$379\text{g}\ (NH_4)_2Cr_2O_7$

How many atoms of oxygen (O) are in 32.1550g of iron (III) carbonate?

$Fe_2(CO_3)_3$

For every one iron (III) carbonate formula there are 9 oxygen atoms.

Conversion factor!!!

$$\frac{9\ \text{O - atoms}}{1\ Fe_2(CO_3)_3}$$

It follows then that if there are nine O – atoms for every one $Fe_2(CO_3)_3$

Then…

there must be nine moles of O – atoms for every one mole of $Fe_2(CO_3)_3$

$$\frac{9 \text{ O-atoms}}{1\ Fe_2(CO_3)_3} \longrightarrow \frac{9 \text{ moles O-atoms}}{1 \text{ mole } Fe_2(CO_3)_3}$$

Conversion factor!!!

How many atoms of oxygen (O) are in 32.1550g of iron (III) carbonate?

$$Fe_2(CO_3)_3 = 291.71 \text{ g/mol}$$

$$32.1550\text{g } Fe_2(CO_3)_3 \times \frac{1\text{mol } Fe_2(CO_3)_3}{291.71\text{g } Fe_2(CO_3)_3} \times \frac{9 \text{ moles O-atoms}}{1 \text{ mole } Fe_2(CO_3)_3} \times \frac{6.022\times10^{23} \text{ O-atoms}}{1\text{mol O-atoms}} =$$

$$= 5.974 \times 10^{23} \text{ O - atoms}$$

Percent Composition:

The relative amounts of each atom in a molecule or compound can be represented fraction of the whole.

Question: What is the weight % of each element in C_2H_6?

Solution:

First determine the molar mass of C_2H_6:

1 mol of C_2H_6 has a mass of 30.07 g **(2×12.01 + 6 ×1.008) g/mol**

Next determine the mass of hydrogen in 1 mol of the compound:

$$1 \text{ mol } C_2H_6 \times \frac{6 \text{ mol H}}{1 \text{ mol } C_2H_6} \times \frac{1.0079 \text{ g H}}{1 \text{ mol H}} = \mathbf{6.047 \text{ g H}}$$

Question: What is the weight % of each element in C_2H_6?

Now relate the mass of H in *1 mol* of the compound to the molar mass (*1 mole*) of the compound

$$6.047 \text{ g H} \times \frac{1}{30.07\text{g } C_2H_6} \times 100 = 20.11\% \text{ H}$$

Since there is only C as the remaining element:

$$\% \text{ C} = 100 - \% \text{ H} = \mathbf{79.89\ \%} \text{ C}$$

The compound C_2H_6 is **20.11**% H & **79.89**% C

Chapter 3: *Electronic Structure and Periodic laws*

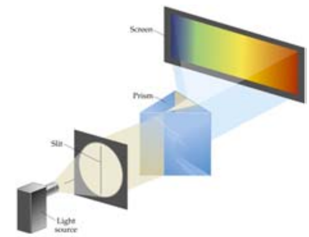
Learning Objectives:

After completing this chapter, the student should be able to:

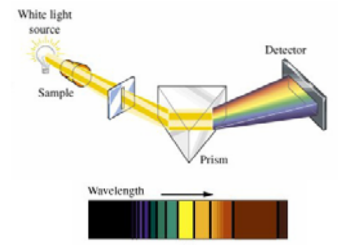
1. Identify elements in the periodic table on the basis of group and periodic designations.
2. Identify the number and types of subshells, orbitals and electrons.
3. Determine the number of electrons in the valence shell of elements as it relates to an element's location on the periodic table.
4. Create and use electronic configurations, including identification of an element and the number of unpaired electrons.
5. Identify the shell and subshell of an element's distinguishing electron.
6. Use the periodic table to classify elements as representative, transition or inner transition.
7. Identify a noble gas, metal, nonmetal or metalloid on the periodic table and relate the properties of these types of elements.
8. Recognize property trends within the periodic table and use those trends to predict selected properties of the elements.

Line Spectra and the Bohr Model

1860: Robert Wilhelm Bunsen and Gustav Kirchoff noted the presence of dark lines arising from absorption of light when observing the spectrum of a bright light source through the flame seeded with alkali metals.



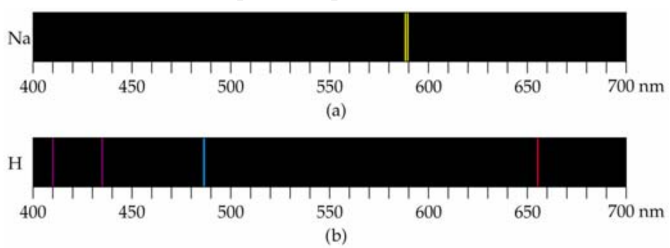
Normal spectrum of white light.



Gaps due to absorption by atoms in the flame

Atomic Line Spectra

Each element has a unique line spectrum.



- The lines indicate that the electrons can only make "jumps" between allowed energy levels.
- Knowing the color (wavelength) on can determine the magnitude of the energy gape using Planck's Law.

The Bohr Model: *A new quantum leap in atomic structure*

Bohr asserted that line spectra of elements indicated that the electrons were confined to specific energy states. These he called orbits.

The lines (colors) corresponded to "jumps" or transitions between the levels.

The Bohr Model:

$r_n = n^2 a_o$

n = 1, 2, 3, 4…